

cal bath, sol-gel, ink, may be used to deposit one or more layers. One or more deposited thin film layers may be formed by at least one of electrodeposition, chemical vapor deposition, chemical bath deposition, sputtering, physical vapor deposition, evaporation, spray coating, spin coating, dip coating, flow coating, ink jetting, plasma spraying, and laser ablation. For superstrate geometry, as shown in FIGS. 6a and 6b, the bulk of the absorber may be annealed prior to deposition of any other material including the embedded electrode.

[0082] In at least one aspect of the present disclosure, a photovoltaic device having a substrate geometry may be made by: 1) depositing planar rear electrode (ITO, metal); 2) depositing planar n-type (or p-type) semiconductor, e.g., CdS; 3) depositing planar p-type (or n-type) semiconductor, e.g., CdTe; 4) patterning and depositing front electrode; and 4) depositing and blanketing majority of p-type (or n-type) semiconductor with an 'absorber', e.g., CdTe. An aspect of the present disclosure having a superstrate geometry may be made by following the above steps 1)-4) in reverse order.

[0083] Properties of the presently disclosed photovoltaic device may be dependent on the geometry of one or more layers. Therefore, lithography may be used to control the geometry of one or more layers. A nonplanar surface topography of one or more layers, the outer layer of the absorber for example, may improve efficiency. The performance of the photovoltaic device of the present disclosure may not be restricted by transparency and conductivity tradeoffs, as with conducting transparent oxides (CTO) and window layers, since there may be no CTO layer in the presently disclosed photovoltaic device. Aspects of the present disclosure may not require precise or high quality lithography since the electrodes are in different layers separated by at least one semiconductor layer, avoiding the shorting of adjacent +/- electrodes. This may permit inexpensive, lower quality patterning of layers that may be patterned.

[0084] While the specification describes particular embodiments and/or aspects of the present invention, those of ordinary skill may devise variations of the present invention without departing from the scope of the claims herein.

1. A thin film photovoltaic device with back contacts comprising:

- a first contact disposed in a first layer and having an upper surface and a lower surface;
- a first semiconductor disposed in a second layer and having a lower surface disposed on the upper surface of the first contact;
- a patterned insulator or a second semiconductor disposed in a third layer and on an upper surface of the first semiconductor;
- a patterned second contact disposed in a fourth layer and on said insulator or said second semiconductor;
- an absorber completely filling a fifth layer and disposed about the second contact; and
- the second layer being adjacent the first layer, the third layer being adjacent the second layer, the fourth layer being adjacent the third layer, and the fifth layer being adjacent the fourth layer.

2. The thin film photovoltaic device of claim 1 wherein said absorber comprises a p-type semiconductor or a n-type semiconductor and said first semiconductor comprises the other of the p-type semiconductor and n-type semiconductor.

3. The thin film photovoltaic device of claim 1 wherein said insulator is disposed in the third layer and said insulator is

configured to insulate against direct electrical communication between said first semiconductor and said second contact and ensure electrical communication between said first contact and said second contact occurs solely through said first semiconductor and said absorber.

4. The thin film photovoltaic device of claim 1 wherein said second semiconductor is disposed in the third layer and is configured to provide electrical communication between said first contact and said second contact solely through first semiconductor and said second semiconductor.

5. The thin film photovoltaic device of claim 4 comprising the limitations of a) or b):

- a) wherein said absorber comprises a p-type semiconductor and said second semiconductor comprises the same or different p-type semiconductor; and
- b) wherein said absorber comprises a n-type semiconductor and said second semiconductor comprises the same or different n-type semiconductor.

6. The thin film photovoltaic device of claim 4 wherein said second semiconductor and said absorber comprise at least one different material.

7. The thin film photovoltaic device of claim 4 wherein said second semiconductor and said absorber comprise the same material.

8. The thin film photovoltaic device of claim 1 further comprising a substrate and said first contact disposed in the first layer has its lower surface disposed on said substrate.

9. The thin film photovoltaic device of claim 1 wherein said absorber fills the interrupts in said second contact.

10. A thin film photovoltaic device with back contacts comprising:

- a first electrode disposed in a first layer;
- a semiconductor disposed in a second layer on said first electrode;
- a patterned insulator disposed in a third layer on said semiconductor and having an interrupted pattern;
- a patterned second electrode disposed in a fourth layer and only on said insulator; and
- an absorber entirely filling a fifth layer and disposed on said second electrode and filling the interrupted patterns of said insulator and said second electrode.

11. The thin film photovoltaic device with back contacts of claim 10 wherein said insulator is comprised of non-semiconducting materials.

12. The thin film photovoltaic device of claim 10 wherein said absorber comprises a p-type semiconductor or a n-type conductor and said semiconductor comprises the other of the p-type semiconductor and n-type conductor.

13. The thin film photovoltaic device of claim 12 wherein said p-type material is selected from the group consisting of: cadmium telluride, copper indium diselenide, copper indium gallium diselenide and copper oxide, and wherein the p-type material is doped or undoped.

14. The thin film photovoltaic device of claim 12 wherein said n-type material is either cadmium sulfide or zinc oxide, and wherein the n-type material is doped or undoped.

15. A back contact thin film photovoltaic device comprising:

- a first contact;
- a first semiconductor disposed on said first contact;
- a second semiconductor disposed on said first semiconductor;
- an interrupted second contact disposed on said second semiconductor; and